RESEARCH PAPER

COGNITIVE TRAINING AS TREATMENT FOR ADHD: EFFECTIVENESS IN SCHOOL-AGED CHILDREN

By

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ABSTRACT

The purpose of this investigation was to ascertain the effectiveness of Captain's Log, a computerized cognitive-training program designed to improve attention and reduce impulsivity. Participants consisting of 48 children in third through sixth grades were nominated by teachers for classroom behavior that interfered with their learning. Students were randomly assigned to either an experimental group or the control condition. All of the students have first completed the Integrated Visual and Auditory Continuous Performance Test (IVA CPT), which served as a pre-test measure of attention and impulsivity. Those assigned to the experimental group then received seven weekly sessions of Captain's Log, each lasting approximately 30 minutes. Those in the control group were excused from class for an equal amount of time, but played a basic computer game (Solitaire) instead. A multivariate analysis of variance (MANOVA) of the post-test measures found that the visual-focused attention scale showed a statistically significant improvement in the experimental group.

Key words: ADHD, cognitive training, school-age, children, Captain's Log

INTRODUCTION

Attention-deficit/hyperactivity disorder (ADHD) is a prevalent childhood disorder that impacts not only those who have the disorder, but all others in their social network. It can be especially troublesome in a school setting, interfering with the individual's ability to concentrate and perform necessary school tasks. Additionally, the behavior of those with ADHD is often disruptive and disturbing to their classmates and especially frustrating for teachers. With an estimated 2-18% of school-age children afflicted with ADHD (Rowland, Lesesne, & Abramowitz, 2002), it is a disorder that has serious implications for school systems. In order to successfully resolve the problematic behaviors associated with ADHD, three key domains must be improved: inattention, hyperactivity, and impulsivity, which constitute the core symptoms of ADHD (APA, 2000; Frick & Lahey, 1991; Shapiro & Herod, 1994).

While there are multiple treatment methods for ADHD, the most commonly employed treatment seems to be stimulant medication (Rowland, et al, 2002; Whalen & Henker, 1991). Stimulant medication has proven highly effective in treating many symptoms of ADHD, with as many as 85% of those with the disorder benefiting from such treatment (Rowland, et al, 2002). However, these psychopharmacology treatments are by no means a miracle cure for ADHD. First of all, they are not effective for everyone who experience ADHD. Further, they have been noted to generate many aversive side effects and may produce even greater rebound effects when discontinued (Barnett & Labellarte, 2001). Another drawback is that these drugs do not teach individuals how to control or modify their own behavior. There are other treatment approaches, such as behavior modification and cognitive-behavioral therapy that do directly educate individuals on ways to improve their thinking and behavior. A similar mode of treatment is computerized cognitive training program, which require children to progress through a series of tasks designed to improve cognitive facilities such as attention skills, inhibition, processing speed, and working memory. One such program is Captain's Log, which not only is reported to produce marked improvement in functioning, but is also reported as enjoyable and captivating by those exposed to it (Slate, Meyer, Burns, & Montgomery, 1998).

The literature pertaining to ADHD is extensive and will only be briefly summarized in this paper. Common symptoms, prevalence rates, treatment approaches, and effect on

academic performance will also be discussed. In additian, methads af assessing ADHD, particularly parent and teacher rating scales and continuous performance tests, will be included. Of particular interest is the Integrated Visual and Auditary Cantinuaus Perfarmance Test (IVA CPT), which will be evaluated in detail. Next, a synopsis of the Captain's Log program will be presented. The review will conclude with overall research findings and implicatians, ratianale, and hypatheses af the current study.

As with multiple ather etiological thearies, the existing explanations for ADHD can be condensed into two broad fields: genetic predispositions and environmental factors (DuPaul & Staner, 2003). There is a plethara af research that emphasizes brain abnormalities or neurological deficiencies as a basis for ADHD (Faraone, 2000; Tannack, 1998). There are also many wha speculate that expasure ta taxic chemicals as a fetus, ar ather birth complications may result in a higher propensity to later manifest symptoms of ADHD (Mick, Biederman, Faraone, Sayer, & Kleinman, 2002; Milberger, Bierderman, Faraone, Chen, & Jones, 1996; Mick, Biederman, Prince, Fischer, & Faraone, 2002). A word of caution should be issued regarding the interpretatian af the variaus etialogical speculations regarding ADHD: mast of the research is based on correlational data and causal explanations are only speculated.

The three core characteristics of ADHD are inattention, hyperactivity, and impulsivity (APA, 2000; Frick & Lahey, 1991; Shapira & Herod, 1994). The DSM-IV-TR (APA, 2000) is commonly used by practitioners to diagnosis ADHD and contains a list of inattention criteria as well as a list af hyperactivity-impulsivity criteria. Based an this, individuals can be classified as either predominantly inattentive, predominantly hyperactive-impulsive, or be characterized by bath. Thase cansidered inattentive must display at least six af the fallawing canditians: inattentian to details or numerous mistakes in activities, difficulty maintaining attention, failing to respond when addressed, failing ta fallaw instructians ar finish prajects, lacking organizational skills, avoiding undertakings that require prolonged attention and effort, frequently misplacing objects, easily distracted, forgetful. The hyperactivity-impulsivity measures (at least six of which must be met) include: being restless ar fidgety, having difficulty remaining seated and being still, running and/or climbing when it is inappropriate to do so, frequently unable ta play quietly, incessantly active, engaging in excessive rambling, impulsively blurting aut answers and having great difficulty refraining from such outbursts, lacking patience in waiting for their turn, habitually interrupting athers. The first six af these criteria describe hyperactive behavior, while the last three pertain to impulsivity. The symptoms displayed must cause impairment in daily functianing, be present befare the age af seven, and be apparent in at least twa settings, such as home or school.

The three key symptoms associated with ADHD are likely to interfere with academic performance in school. Accarding ta Alyward, Bell, and Gardan (1995), "The ability to sustain attention and inhibit responding is central to general academic achievement" (p. 2). Specifically, the inability ta facus and maintain attentian aver extended periads af time disrupts the acquisitian af knowledge in the classroom (Barry, Klinger, Lyman, Bush, & Hawkins, 2001; Das & Papadopoulos, 2003; Gordon, Mettelman, & Irwin, 1994). Sustained attentian deficits may interfere with the ability ta facus an lessans as the teacher explains them. If students do not initially acquire the pertinent infarmatian, they lack the knawledge ta perfarm well an future assessment af material. Gardan, et al. (1994) found that individuals who have repeated a grade in school scored significantly lower on measures of sustained attentian than did thase wha never retained. They suggest that the inability to focus on relevant information and to sustain attention is a key factor in academic failure.

It has also been determined that ADHD children suffer fram paar warking memaries. In a classraam setting, working memory cantributes to aspects such as note taking, completing assignments, and doing well on examinations; thus, thase who have a deficient working memory will do paorly an all such tasks. Another camman academic hindrance associated with ADHD is lack of

mativatian (Barkley, 1998). However, this lack af mativatian may nat be a direct result af the disarder; it may be the result of difficulties associated with the disorder such as paor sustained attentian and inability ta grasp cancepts. Cantinued failure due ta these attentian problems likely discourages ADHD individuals, which then results in poor motivation. "Furthermore, many such children develap secandary ematianal prablems as a consequence af the frustrations and failures they experience" (Silver, 1981, p. 396).

The poor academic performance of those with ADHD and the aversive consequences it causes them and the entire schaal system is well dacumented in the literature. When compared ta narmal cantrals, hyperactive individuals have been found to complete lower levels of education, which is likely the result of repeated years of academic struggle (Weiss, Hechtman, Milray,& Perlman, 1985). Many have found that those with attention disorders are commonly academic underachievers, are likely ta be placed in special educatian classes, and are more likely than those without attention deficits to be retained in school (Barkley, 1998; Cantwell, 1996; Frick, et al., 1991; Frick & Lahey, 1991; Gardan, et al, 1994; Reid, Maag, Vasa & Wright, 1994). In a three year langitudinal study of academic achievement in a group of boys who were referred for clinical treatment, Frick, et al. (1991) discavered that underachievement was assaciated with the presence af ADHD. It has further been noted that approximately 30% of ADHD children may repeat a grade in school, and 30-40% require special education courses (Barkley, 1998). Children with ADHD are aften disruptive in class and interfere with the learning process of other students (DuPaul & Stoner, 2003). They may distract athers by fidgeting in their seat, repeatedly leaving their seat, continually tapping their hands and feet, making frequent outbursts, and inappropriately talking ta their classmates. Thus, ADHD is nat anly disruptive ta thase children wha have the malady, but it is also taxing for the schools in terms of extensive time and resources that are spent educating and disciplining them.

A pramising new treatment far ADHD is camputerized training. Xu, Reid, and Steckelberg (2002) stress the new and unique aptians that technalagy affers in the treatment of children with ADHD, stating such notable contributions as the ability to "simulate real world situatians with images and saunds . . . pravide step-by-step instruction, wait for responses, and offer immediate feedback and reinforcement" (p. 224-225). DuPaul and Staner (2003) testified that camputer-assisted instructian is very advantageous in teaching new skills to those with attention disorders because computer programs can "readily present specific instructional abjectives, pravide highlighting af essential material, use multiple sensary modalities, divide content material into smaller bits of information, and provide immediate feedback about respanse accuracy" (p. 181). While there is currently very limited research examining the use of technology in treating ADHD individuals, the findings that are present have been extremely positive.

Computerized Cognitive Training Program

Captain's Log is a structured computerized cognitive training pragram that has been successfully used in the past to imprave attentian and reduce behavioral impulsivity (Kotwal, Burns, & Montgomery, 1996; Slate, et al, 1998). The program consists more than eight hours of training, with a tatal af 33 exercises campiled inta five modules. The exercises are constructed in a game format so that the participants can enjoy the learning process. Participants begin with easier tasks and pragress thraugh increasingly mare challenging tasks. The training exercises are designed to improve such facets as general attention, focused attention, sustained attention, visual and auditary pracessing speed, warking memary, self-control, motivation and self-esteem.

Katwal, et al. (1996) had a child with ADHD participate in the Captain's Log training program for a total of 35 sessions. In order to pragress fram one level to another mare difficult level, the subject had ta make na mistakes (a perfect score of 100%) on two consecutive task trials. Parents and teachers completed surveys and reported an the child's behaviar, and bath nated an impravement in behavior during and after completian af the training. The most notable improvement occurred in classroom

behavior, as reported by his teacher. Further, the child reported enjoying the computerized training program. Thus, this program was not only successful in improving attention skills, with the improved attention and inhibition generalizing to the classroom, but was also considered enjoyable by the participant. The researchers contended that this program hod potential as a new form of treotment for attention disorders or, ot the very least, os a supplement to other forms of treatment.

A few years later some of the same researchers conducted a similor study using a sample of four children with severe emotional disturbonces who were currently living in a youth treatment facility (Slate, et al. 1998). In addition to ADHD, the children suffered disorders such as posttraumatic stress disorder, conduct disorder, bipolar disorder, and psychotic disorder. While in the focility, these children were receiving both medication and behavior modification treotments, the researchers wonted to determine if the oddition of Coptain's Log cognitive training could improve their functioning. Each participant completed 30-minute sessions of the program, four times a week for a totol of 16 weeks. A comporison of pre and post IVA CPT tests confirmed that all of the porticipants improved their attentional performance after completing the Captoin's Log program, and all showed greater impulse control ond less hyperoctivity in their daily functioning as well. The researchers noted that the program was an excellent supplement to the more troditionol forms of treatment. Once again, the participants reported that the program was very engaging and rewarding and even requested to continue the troining after the study concluded. Thus, studies utilizing Coptain's Log have found very encouraging results and received positive feedback from all participants, suggesting that it is a viable alternative for those who do not respond or wish to undertake the more traditional treatments for attention disorders.

Most reseorch on ADHD children has involved those who are referred for clinical treatment with very little research conducted on those in school settings (Reid, et ol. 1994; Rowland, et al. 2002). These samples of children may not occurately represent the generol population of children with ottention disorders. Children referred for clinical treatment may exhibit more acute symptoms, may more outwardly express their symptoms and disploy more hyperoctivity, may be especially disruptive to others, and may also manifest other co-occurring disorders. It is likely thot most children who struggle with ottention problems ore not os outwardly disruptive ond thus go unnoticed or ot least ovoid referral to clinicians. This study ottempts to examine how attention disorders are expressed in a school population ond thus clarify differences from those in a clinicol sample.

Hypothesis

Those who porticipote in the Coptain's Log training program will show marked improvements in attention and impulsivity, as measured by the IVA CPT.

Methodology

Participants

Participants for this study were recruited from a rural school in southeast Texas that encompassed third through sixth grades. Students were nominated by teachers who hod identified them as having attention ond/or impulsivity problems that either interfered with their ability to learn or disrupted the learning process of their fellow classmates. A totol of 80 students were recommended for inclusion in the study and were provided with parentol consent forms to take home to get consent from their parents. Parental consent was granted for 50 students, who were then randomly assigned to either an experimentol condition or o control condition. Two participants (one from the experimental group and one from the control group) were subsequently eliminated from the study due to suspension from school and noncompliance.

The finol 48 porticiponts included 30 moles (63%) and 18 females (37%). The porticipants ranged in age from 8 to 12, with a mean age of 9.92. The sample included 15 (31%) third grade students, 10 fourth grade students (21%), 12 fifth grade students (25%), ond 11 sixth grade students (23%). The sample was ethnically diverse, being comprised of 28 Caucasian students (58%), 12 African American students (25%), and 8 Hispanic students (17%).

Materials

Students first taak the Integrated Visual and Auditary Continuous Performance Test (IVA CPT). This computerized test, lasting approximately 20 minutes altogether, examines issues af inattentian and impulsivity. A series af numbers, either "1" or "2", are visually displayed on the computer screen or orally spoken by a female voice, and participants are instructed to click the mause button when they see ar hear a "1" but refrain from clicking the mouse button when they see or hear a "2". At times, the number "1" is a very comman, frequently presented stimulus, which praduces a situatian in which errars af commission are likely to occur. Other times, the number "1" is rarely presented, a circumstance that promotes errars af amissian. Thus, the IVA CPT assessed participant's ability ta facus and sustain their attentian and nat respand impulsively to distracter stimuli.

The IVA CPT produces a global rating of attention and a global rating of response inhibition, as well as six subscales: prudence, consistency, stamina, vigilance, focus, and speed. Furthermore, each of the subscales includes an auditory and visual component, carresponding to the auditary and visual stimuli presented in the test. The measures af prudence, consistency, and stamina are considered subscales of response inhibition, while vigilance, focus, and speed are classified as attentian variables. Prudence measures participants' ability ta think befare they respond and avoid impulse errors (inappropriately responding to the number "2"). Consistency determines the regularity of response times thraughaut the task, while stamina cancerns maintenance of response times and whether participants were able to stay focused for the duration of the 15-minute test. Vigilance measures the ability ta identity correct targets (the number "1"). The focus scale establishes the extent to which participants are able to remain attentive during the entirety af the test, and speed calculates the amaunt af time taken ta respand ta correct stimuli. Of note is that assessment of ADHD using the IVA-CPT has been shown to be more resistant to malingering than the mare camman rating instruments (Quinn, 2003).

An additianal camputer pragram that was emplayed was the Captain's Log cagnitive training pragram, which was completed by students in the experimental group. Captain's Log is designed to improve cognitive skills such as facused attentian, sustained attentian, alternating attention, processing speed, and working memory. It also aims to train participants to control their initial impulses and think befare respanding. The exercises in the Captain's Lag pragram are arganized in such a way that they become increasingly more difficult. Thus, as participants pass each level, they progress to gradually mare difficult levels and restrictive instructians with added stimuli to which they must attend. At some of the higher levels, participants are given no explicit instructions, but instead are required ta determine far themselves, thraugh trial and error, what the specific rule is.

In arder ta pass a task and mave an ta anather, participants must correctly identify and respond to the stimuli as they are instructed. They are limited on the number af errars allatted, and they must respand in a timely fashian, as respanse time is an additional factor. Thus, it is possible to correctly identify all of the correct stimuli, yet fail ta pass the stage due ta inadequate respanse time. If a participant fails ta pass the first stage, they must continue until they do successfully complete the requirements of that level. If they fail in any successive stages, they are immediately dawngraded ta the preceding stage.

Procedure

Students with attentian disarders, as determined by their teachers, were selected as possible participants in a computerized cognitive training program designed to imprave their attentian and respanse inhibitian. Once the students and their parents agreed ta participate in the study by signing an informed consent form, the students were randomly assigned to either an experimental canditian ar ta a cantral graup. Participants in bath conditions first completed the IVA CPT, which served as a pre-test to which future performance was compared. Thase in the experimental canditian then campleted a weekly sessian af the Captain's Lag pragram for a total af

seven weeks. Sessians were divided inta 25-minute blocks, with two students from the experimental group and two from the control group present for each session. The cantral graup was extracted fram class just as the experimental graup was and played Salitaire on the computer instead of engaging in Captain's Log. At the conclusion of the seven-week treatment program, all participants again campleted the IVA CPT, which served as a post-test to compare to the original pre-test.

Results

Data were analyzed using Multivariate Analyses af Variance (MANOVA) in which the two groups, experimental and control were compared on several measures af the IVA CPT past-test administered after the seven-week treatment pragram. As mentianed previously, IVA CPT measures of interest included global response inhibition, global attention, and the six subscales af prudence, cansistency, stamina, vigilance, focus, and speed. The response inhibition subscales (prudence, consistency, and stamina) were analyzed separately fram the attentian categaries (vigilance, facus, and speed). Although there were a number af analyses conducted, alpha was set at .05 due to the exploratory nature of the study.

The experimental and control groups exhibited extremely variable scores an bath glabal measures (respanse contral and attention), as is evidenced by their large standard deviations. Descriptive statistics for both groups are presented in Table 1.

The two groups were then analyzed for differences in glabal respanse inhibitian and attentian scares using a MANOVA. Unfartunately, these results did nat reach statistical significance. The two groups did not statistically differ in their post-test IVA CPT measures of global respanse inhibitian ar attentian.

Source	Group	Meon	Std. Deviotion
Response Control	Experiment	86.29	19.128
	Control	76.54	21.317
Attention	Experiment	81.37	26.909
	Control	76.29	25.175

Table 1. Descriptive Statistics for Global Response Control and Attention

Next, the groups were analyzed for differences on each of the subscales of response inhibition. These categories include prudence, cansistency, and stamina, and each is further classified as auditory and visual. There were no significant differences between the experimental and cantral graups an any af the respanse inhibitian measures.

Anather MANOVA examined the graup's past-test scares on the IVA CPT attention subscales of vigilance, focus, and speed. Similar to the response control measures, these alsa include bath an auditary and visual campanent. One of the attention categaries, visual facus, did show a significant difference on the post-test score (F (1, 47) = 4.56, $p < .05$). The focus scale measures the participant's ability ta sustain attentian and maintain cansistent and reliable response patterns. None of the other attention scales demonstrated statistically significant differences. The results af the MANOVA are shawn in Table 2.

Of all the variables analyzed, only ane factor was found to be statistically different an the IVA CPT past-test, and that was visual focus, one subcategory of the attention appraisal. None of the other attention subscales, or any of the respanse inhibitian subscales shawed any significant difference an the past-test. Further, the glabal measures of attention and response inhibition also failed to show evidence of significant change an the past-test. It seems that in this examinatian af the utility af Captain's Lag cognitive training program, only visual focused attention was improved in a seven session training period. Student's ability ta sustain their visual attentian aver the duration of the test and to consistently respond to the target stimuli did improve as a result of cognitive training. Hawever, as visual facused attentian was the anly aspect that shawed impravement, anly a small partian af

Source	SS	DF	MS	F	Sig. of F
Vigilonce (Aud)	346.687	1	346.687	.464	.499
Vigilonce (Vis)	.000	1	.000	.000	1.000
Focus (Aud)	540.021	1	540.021	.177	.676
Focus (Vis)	1397.521	1	1397.521	4.559	.038
Speed (Aud)	588.000	1	588.000	1.720	.196
Speed (Vis)	825.021	1	825.021	2.307	.136

Table 2. Summary of MANOVA for Attention Subscales

Hypothesis 1, which stated thot those who participate in the Captain's Log training program will show morked improvement in attention and impulsivity, was supported.

Discussion

Attention disorders are prevolent in school-aged children and frequently interfere with their academic pursuits. A lack of attention in school, os well os impulsive behavior, often inhibits the leorning process. Further, such children often monopolize a teacher's time, disrupt their classmates learning, and command a great deal of resources from the school district. The impact of attention disorders not only impacts those with the disorder but also pervades many of the networks with which they are involved, porticularly the school system where they spend most of their time.

For these reosons, it is imperative to identify possible school-based interventions for ottention disorders. This study examined one possible intervention that could be implemented in schools, Captoin's Log computerized cognitive troining program. This progrom wos chosen because of its many unique features and because previous studies hove revealed very promising results. However, only two such studies have been published and they contained several shortcomings. The current research project attempted to expand previous investigations while addressing some of their limitotions. However, despite high expectations for success, this study found only limited benefit to the participants. The measure thot showed improvement after sessions of Captain's Log was the visuol focused attention subscole. Of course, visual focused attention is an important factor for success in school and other venues. The other subscoles of the globol factors (attention and response inhibition) showed no significant difference after treatment.

There are several possibilities as to why this experiment did not produce more changes on the post-test. The short durotion of the treatment period is one of the reasons; the experimental group received seven 30-minute sessions of Captain's Log for a total of three and half hours of program time, moy hove been inadequate for meosurable effect. In two other studies of Captoin's Log, participants completed 35 ond 64, 30-minute training periods of the program (Kotwal, et al, 1996; Slate, et al, 1998). This is much more thon the seven performed in the current study. While it would have been desirable to conduct greoter number of sessions, the school schedule and research timeline prevented doing so. However, the current results showing at least one significant effect holds promise that more exposure might present greater effect.

Additionally, in the current study four students were present at each session. It is possible that the presence of the other students interfered with concentration on the Captain's Log program. However, students were seoted such to see their computer monitor in an ottempt to promote full attention to the task at hand. At times, there were unavoidable distractions during the pre-testing, training sessions, and the post-testing. Teachers or other students sometimes entered the room, announcements were occasionally made over the intercom, and noisy groups sometimes loitered outside the door. These distrocting events, particularly during the post-testing, could have altered a student's scores. It is also possible thot the attention poid to the control group and the experience of playing Solitaire moy hove had positive effects on them.

Conclusion

In conclusion, while the current study found only limited significant changes in attention and response control after o treatment regime of Captain's Log, more exposure may render the program a useful treotment. Previous studies that performed mony more sessions of the program found extremely positive, lasting results. There is good reason to believe that future studies which implement a higher number of training sessions will also improve the level of attention and impulse.

The most notoble limitotion of this study wos the limited time allotted for Captain's Log training. Seven 30-minute sessions were not enough training time to produce improvements in ottention and inhibition. Another limitation is the small sample size. While this study did include a much larger sample than previous Captoin's

Log studies, it wos still a relatively small somple of students. Furthermore, having multiple students at a time in the testing room was likely distracting and detracted from the program's effectiveness.

Future studies should concentrate on implementing Captain's Log in a school-based sample of children. Children spend much of their time at school and their lock of attention and impulsivity adversely impacts their learning abilities ond also detracts from their classmate's education. Teaching those with attention disorders is also very toxing for schools. Treating attention disorders in the school would benefit all involved.

Further studies should also implement the training program for a longer period of time. A program that ron for an entire year or even one ocademic semester could provide an abundant amount of information regarding the program's effectiveness. Additionally, considering a student's course grades could be useful in determining generolizability to the clossroom.

Testing the program on different populations could also be useful. One recommendation is to utilize the program with student's involved in special education closses. Additionally, children of different ages should be exomined. This study employed children in third through sixth grades. It would be useful to observe how both younger and older children respond to the program.

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